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FINAL REPORT
REACTION WHEEL ASSEMBLY

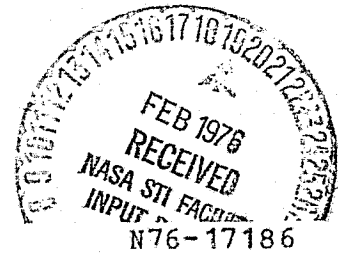
JANUARY 1976

Contract No. NAS 8-31385

Prepared For
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Marshall Space Flight Center
Alabama 35812

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(NASA-CE-144168) REACTION WHEEL ASSEMBLY
Final Report (Sperry Phoenix Co.) 16 p HC
\$3.50 CSCL 22B



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G3/18 13602

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I. INTRODUCTION

This document is the final report for Contract Number NAS 8-31385, and is submitted to fulfill Paragraph 2 of the Reports Requirements, Exhibit "B" to that contract. The program consisted of the fabrication of three Reaction Wheels with associated drive and system monitoring electronics with brushless dc spin motors. They are intended for use on the MSFC Teleoperator Simulator. These reaction wheels were a modification of the existing Sperry Model 15 design incorporating the dc motor and drive electronic circuits from another Sperry design along with a speed pickoff which operates down to zero speed.

In order to execute the program within the required period it was necessary to make use of existing hardware. The first unit was built using an existing prototype wheel which had previously been used at Sperry to test various design concepts. Although the performance of this wheel is identical to the other two, the external appearance is somewhat different because of attachment points which had been machined into the housing.

The following sections provide a summary of the work accomplished and the equipment performance.

II. PROGRAM STATUS

The program was authorized on 18 June 1975 for a six month period. The following equipment and documentation were shipped to MSFC.

<u>Equipment</u>	<u>Shipped</u>
Reaction Wheel S/N 5100001	Nov. 1975
Reaction Wheel S/N 5100002	Jan. 1976
Reaction Wheel S/N 5100003	Jan. 1976

Documentation

Progress Reports

Drawings

Test Procedure

Operation Manual

Test Report

Final Report

Shipped

6 reports - 1 per month

Oct. 1975

Sept. 1975

Oct. 1975

3 reports - 1 w/each unit

Jan. 1976

The completion of program milestones is shown on the bar chart, Figure 1.

III. EQUIPMENT PERFORMANCE

The performance and characteristics of the units are shown in the Table I which follows. Complete test results are contained in the Test Reports for each unit which have been submitted under separate cover. The principal measurements and calculations were done with English Units and the values converted to SI units for Table I.

The comments below explain the performance values listed for each unit.

Weight - Minor differences occur because of machined part tolerances.

Rotor Unbalance - Typical balance requirements for this size wheel are 3.6 gm-cm (0.05 oz-in) static and 100 gm-cm² (0.5 oz-in²) dynamic.

Rotor Inertia - Variations are due to machining tolerances and weight removal for balancing.

Angular Momentum - Calculated from rotor inertia.

Insulation Resistance - Variations occur due to wire routing and part cleanliness.

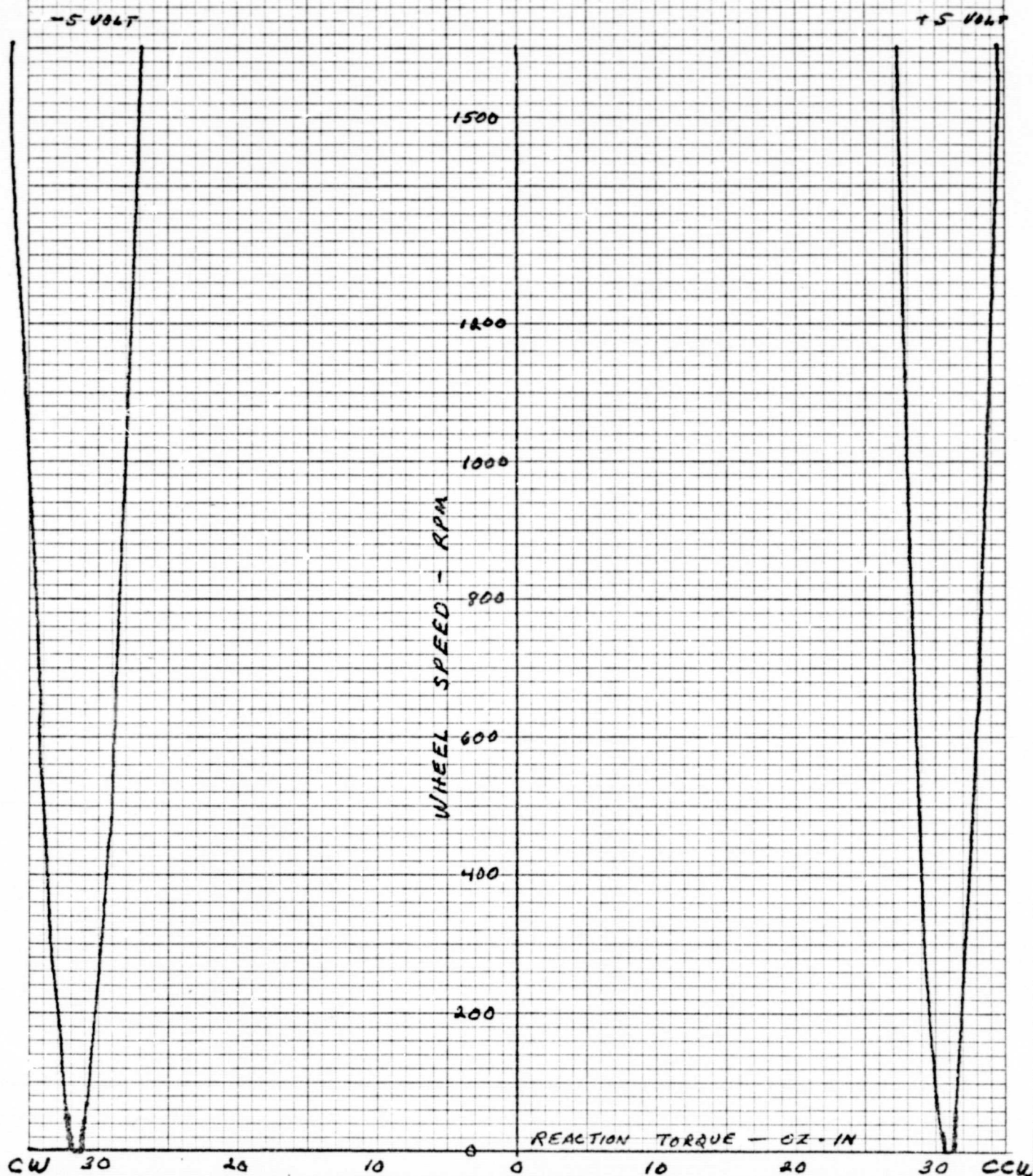
REACTION WHEEL ASSEMBLY SCHEDULE

Month	July	Aug	Sept	Oct	Nov	Dec	Jan
Drawing Preparation	▶						
RWA Fabrication							
Parts Procurement	▶	▶	▶	▶	▶		
Mechanical Subassembly				▶	▶		
Electronic Subassembly		▶	▶	▶	▶	▶	
RWA Testing							
Test Procedure		▶	▶				
Calibration				▶	▶	▶	
Acceptance Test					▶	▶	▶
RWA Delivery					▶	▶	▶
Documentation							
Monthly Reports	▶	▶	▶	▶	▶	▶	
Accept. Test Proc.			▶				
Accept. Test Data					▶		
Drawings					▶		
Operation Manual					▶		
Final Report							▶

Figure 1

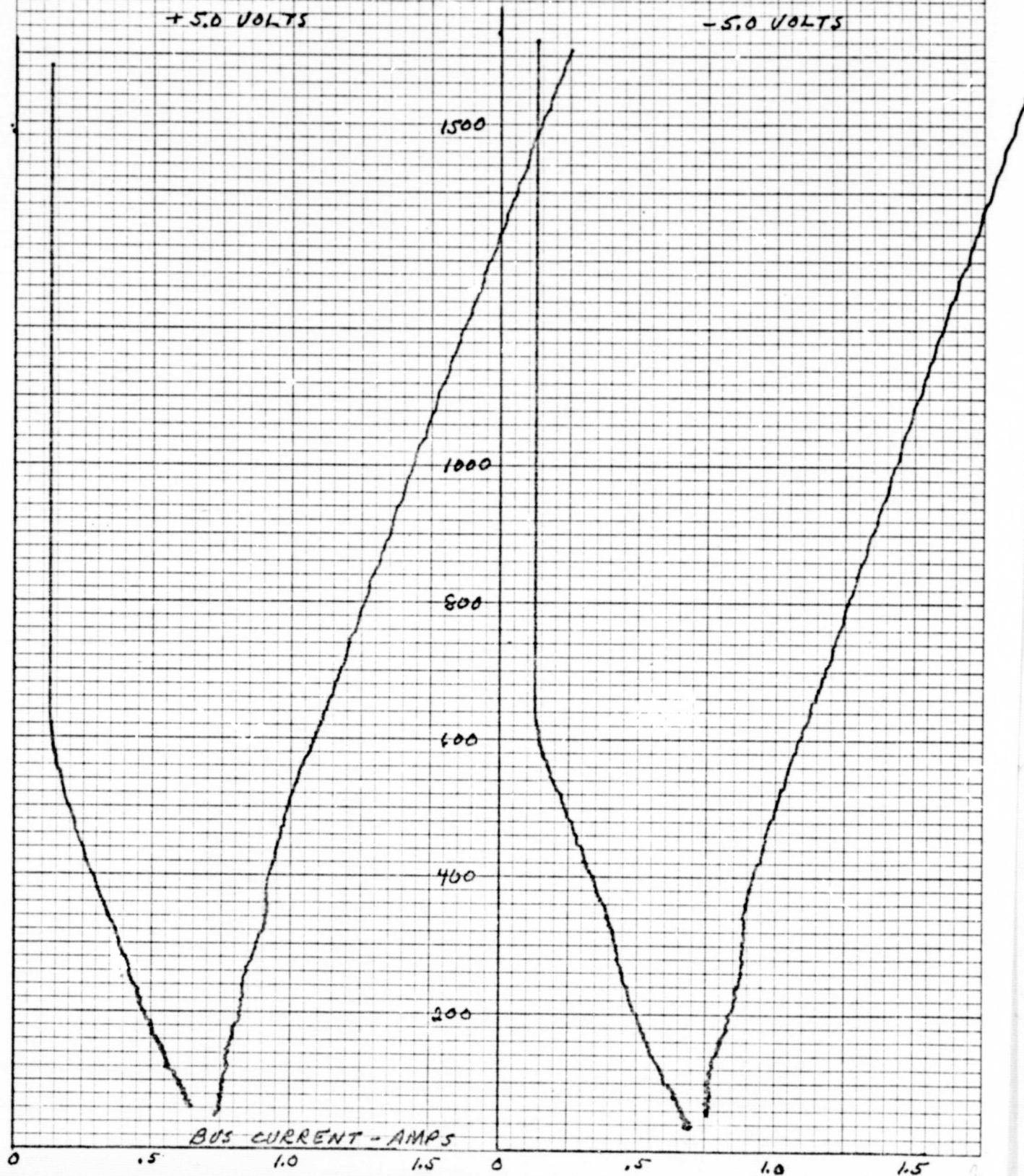
SER NO 6001
5.0 VOLT COMMAND
28 VOLT EXCITATION
4 NOV 75

Fig. 2 Sheet 1



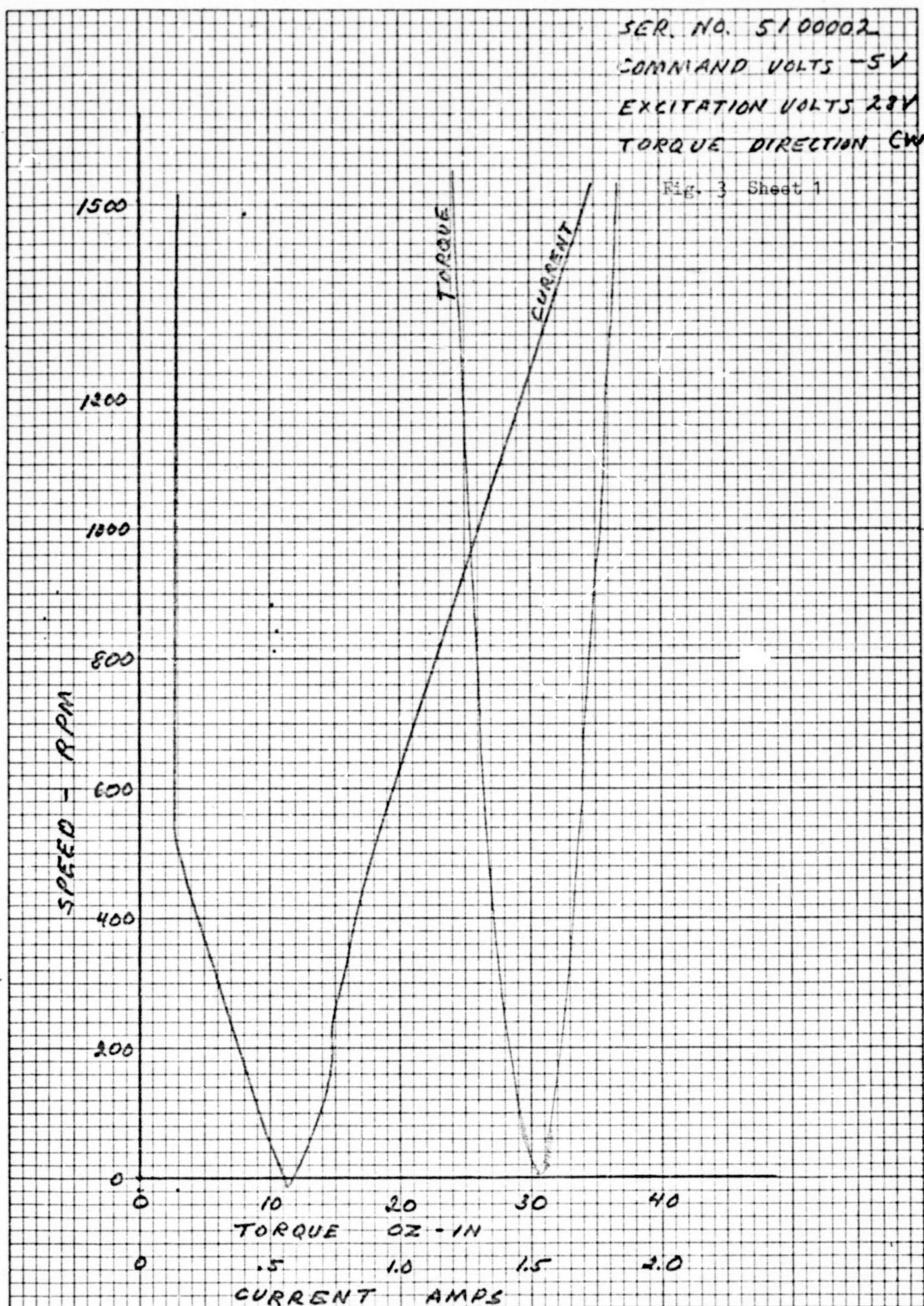
SER NO 0001
5 VOLT COMMAND
28 VOLT EXCITATION
4 NOV 75

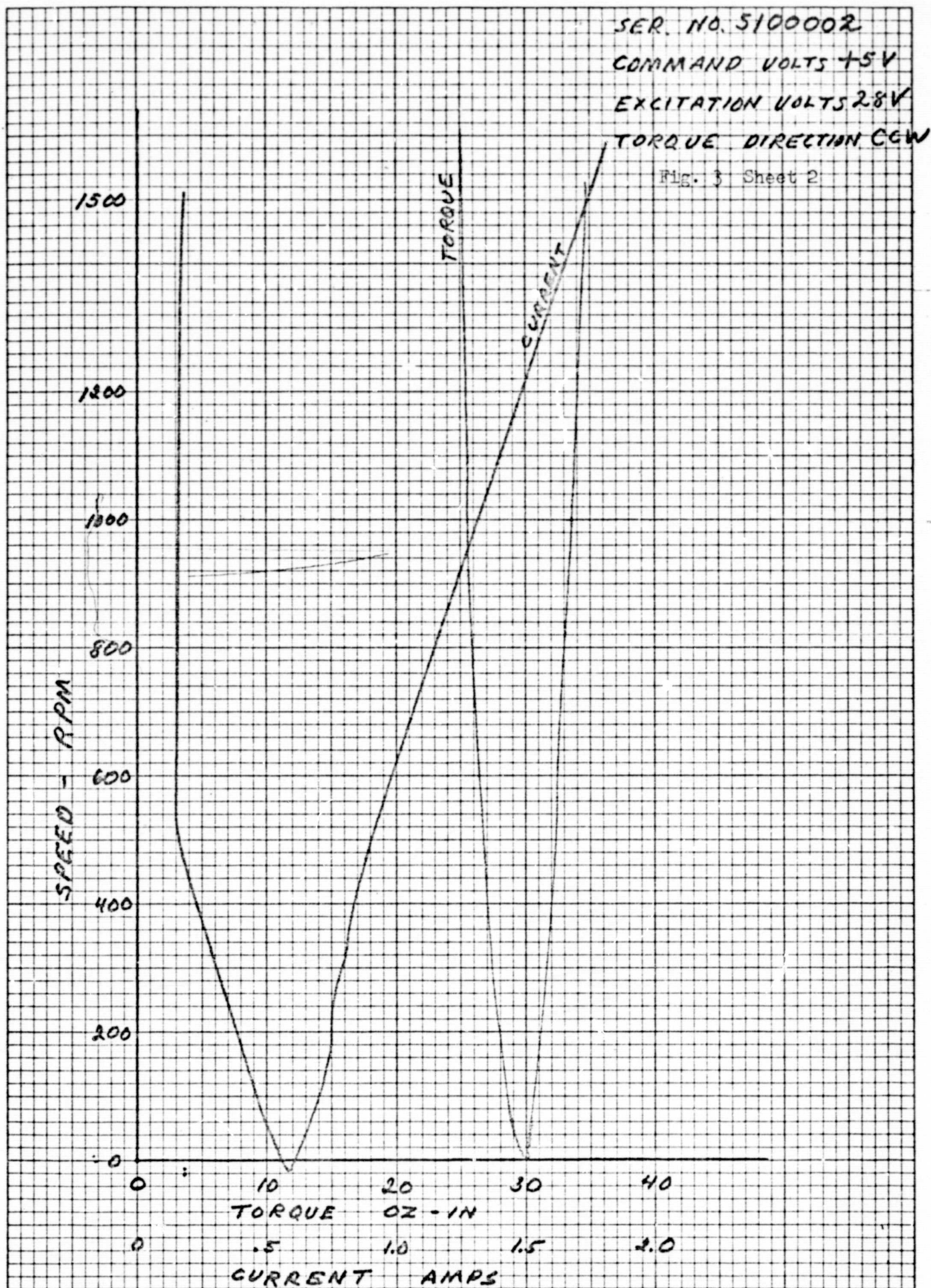
Fig. 2 Sheet 2



EUGENE DIETZGEN CO.
MADE IN U. S. A.

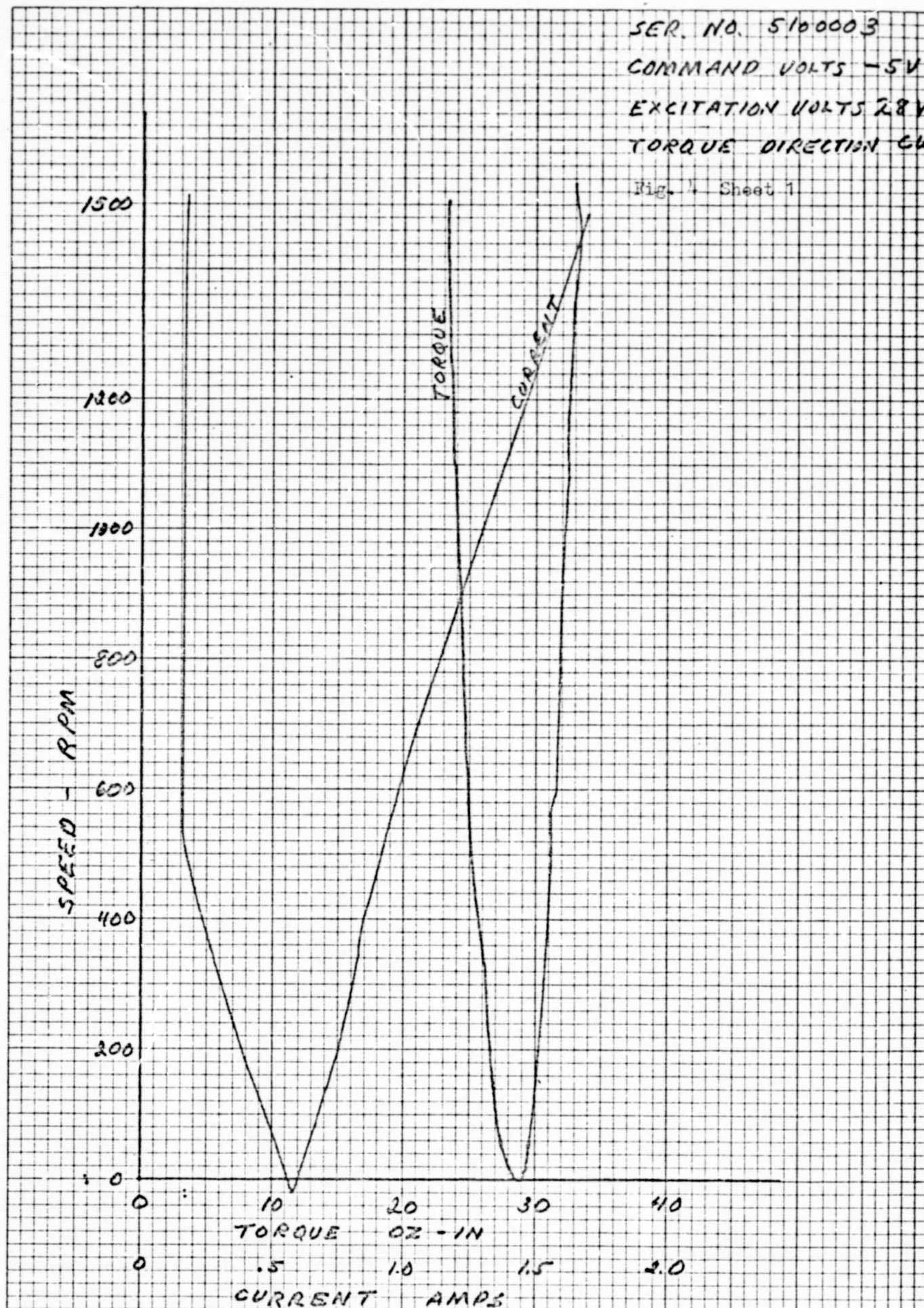
NO. 340R-10 DIETZGEN GRAPH PAPER
10 X 10 PER INCH

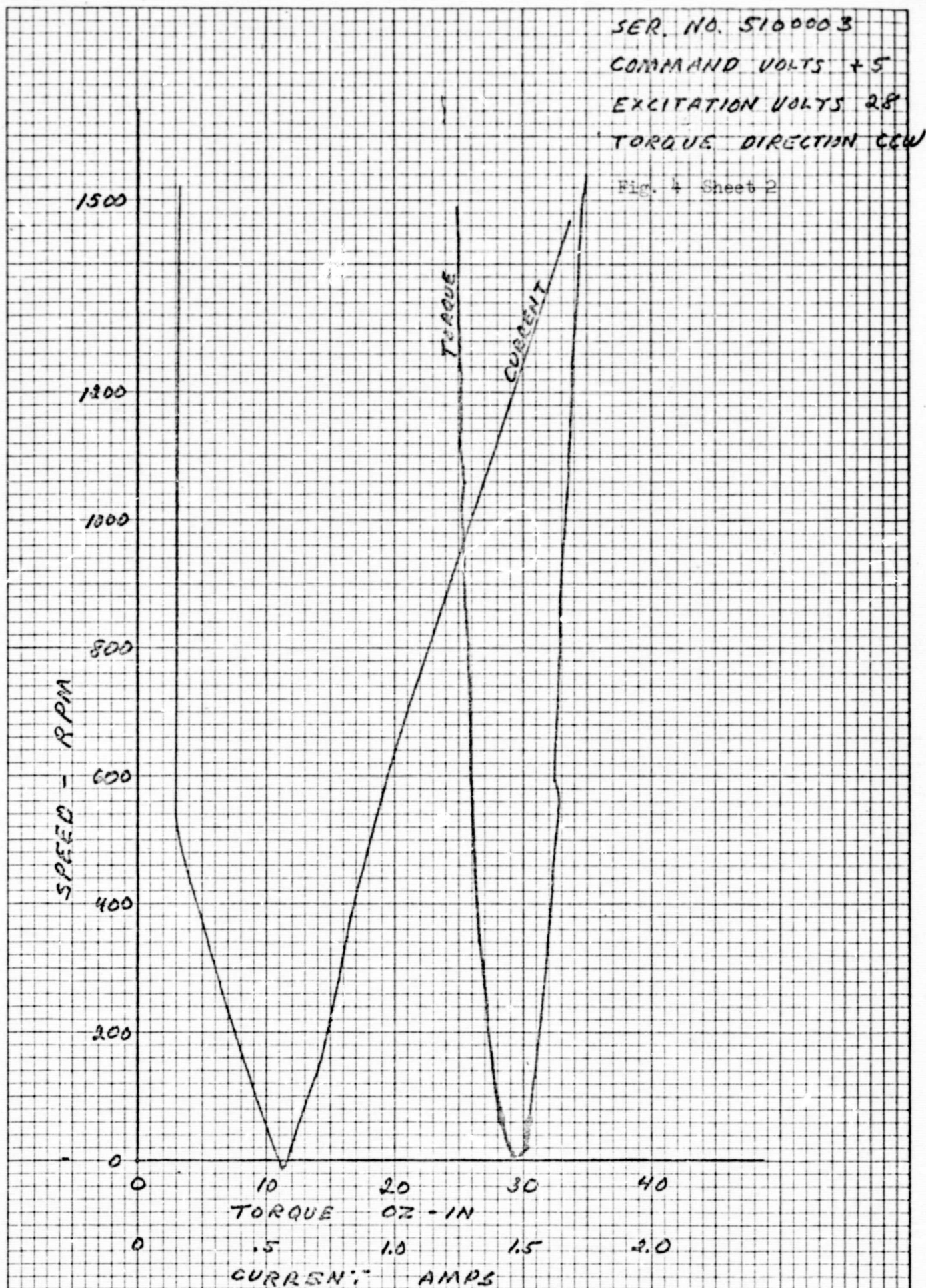




SER. NO. 5100003
COMMAND VOLTS -5V
EXCITATION VOLTS 28V
TORQUE DIRECTION CW

Fig. 1 Sheet 1





Pressure Rise Rate - Rate for S/N 5100001 was lower because additional effort was expended in cleaning and outgassing to solve a high pressure rise rate problem. The problem was found to be covers over the motor windings which prevented effective cleaning but were not a good enough seal to prevent outgassing. These covers were vented to solve the problem.

Tach Pulse Height - Value is determined by standard TTL circuit performance.

Direction Signal - Value is determined by standard TTL circuit performance.

Output Torque - Typical performance is shown on the curves of Figures 2, 3 and 4. Additional curves for 2.5 and 5.0 volt commands and 24, 28 and 32 volt excitation are included in the Test Reports. The curves for S/N 5100001 (Fig. 2) have a different format because a two channel recorder was not available at the time of test.

Constant Speed Power - Minor variations are caused by part and calibration tolerances.

Torque Time Constant - Variations caused by part tolerances and measurement errors.

Drag Torque - Both bearing drag and motor drag torques are included in the value given. Bearing drag varies because of differences in lubricant amount and location. Motor drag variations occur because the motor drive electronics are attempting to maintain zero current but zero offsets and other errors allow some motor current to flow.

Breakout Torque - Variations occur because of motor torque ripple and accuracy of electronics calibration. The test results given were obtained by gradually increasing command voltage until the rotor continued to turn. In Figures 5 and 6 a triangle shaped command voltage was applied while recording the reaction torque output. The

TABLE I

REACTION WHEEL PERFORMANCE CHARACTERISTICS

<u>Parameter</u>	<u>Units</u>	<u>Requirement</u>	<u>S/N 5100001</u>	<u>S/N 5100002</u>	<u>S/N 5100003</u>
Weight	newton (pounds)		92.79 (20.86)	93.76 (21.08)	93.85 (21.1)
Rotor Unbalance Static	gm-cm (oz-in)		0.79 (0.011)	0.61 (0.0085)	0.60 (0.0083)
Dynamic	gm-cm ² (oz-in ²)		1.10 (0.006)	7.50 (0.041)	1.10 (0.006)
Rotor Inertia	Kg-m ² (ft-lb-sec ²)		0.0734 (0.0541)	0.0724 (0.0535)	0.0734 (0.0541)
Angular Momentum at 157.08 rad/sec (1500 rpm)	n-m-s (ft-lb-sec)	11.4 (8.4)	11.52 (8.498)	11.39 (8.404)	11.52 (8.498)
Insulation Resistance	megohms		13,000	200,000	25,000
Pressure Rise Rate	n/m ² /sec (micron/day)		0 (0)	7.8x10 ⁻⁸ (2)	1.95x10 ⁻⁸ (.05)
Tach Pulse Height	volts		3.4	3.4	3.7
Direction Signal CW	volts		0.078	0.097	0.099
Direction Signal CCW	volts		3.89	3.9	4.1
Output Torque	n-m (oz-in)	0.21 (30)	Fig. 2	Fig. 3	Fig. 4
Constant Speed Power 0 RPM 28 v	watts		4.5	5.13	4.48
1500 RPM 28 v	watts		9.5	10.03	9.8

REACTION WHEEL PERFORMANCE CHARACTERISTICS (Continued)

<u>Parameter</u>	<u>Units</u>	<u>Requirement</u>	<u>S/N 5100001</u>	<u>S/N 51000002</u>	<u>S/N 5100003</u>
Torque Time Constant	sec		0.1	0.11	0.08
Drag Torque	n-m (oz-in)		0.021 (3.0)	0.030 (4.25)	0.028 (4.0)
Breakout Torque	n-m (oz-in)		0.0079 (1.12)	0.0095 (1.35)	0.014 (1.99)

Figure 5

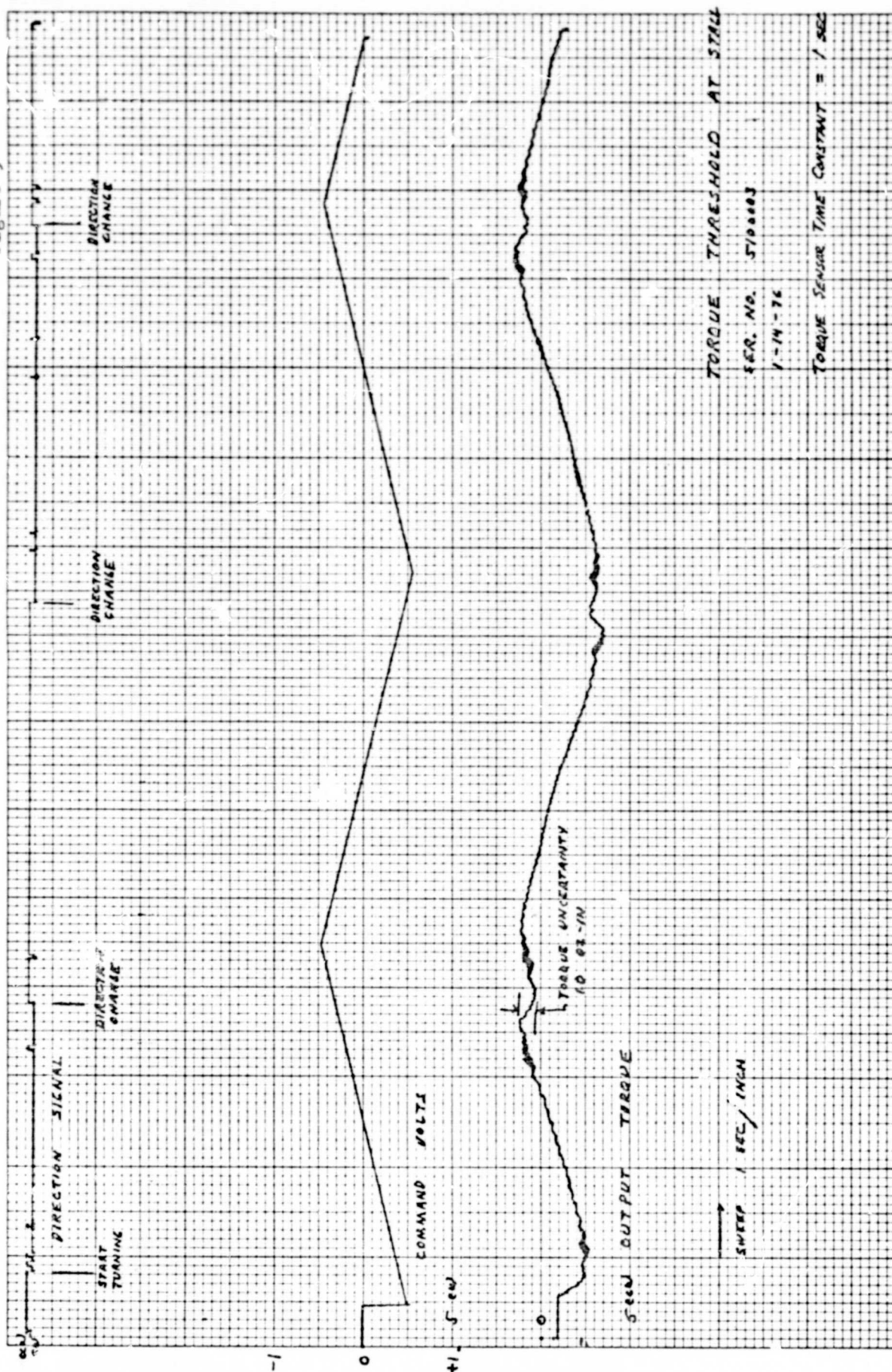
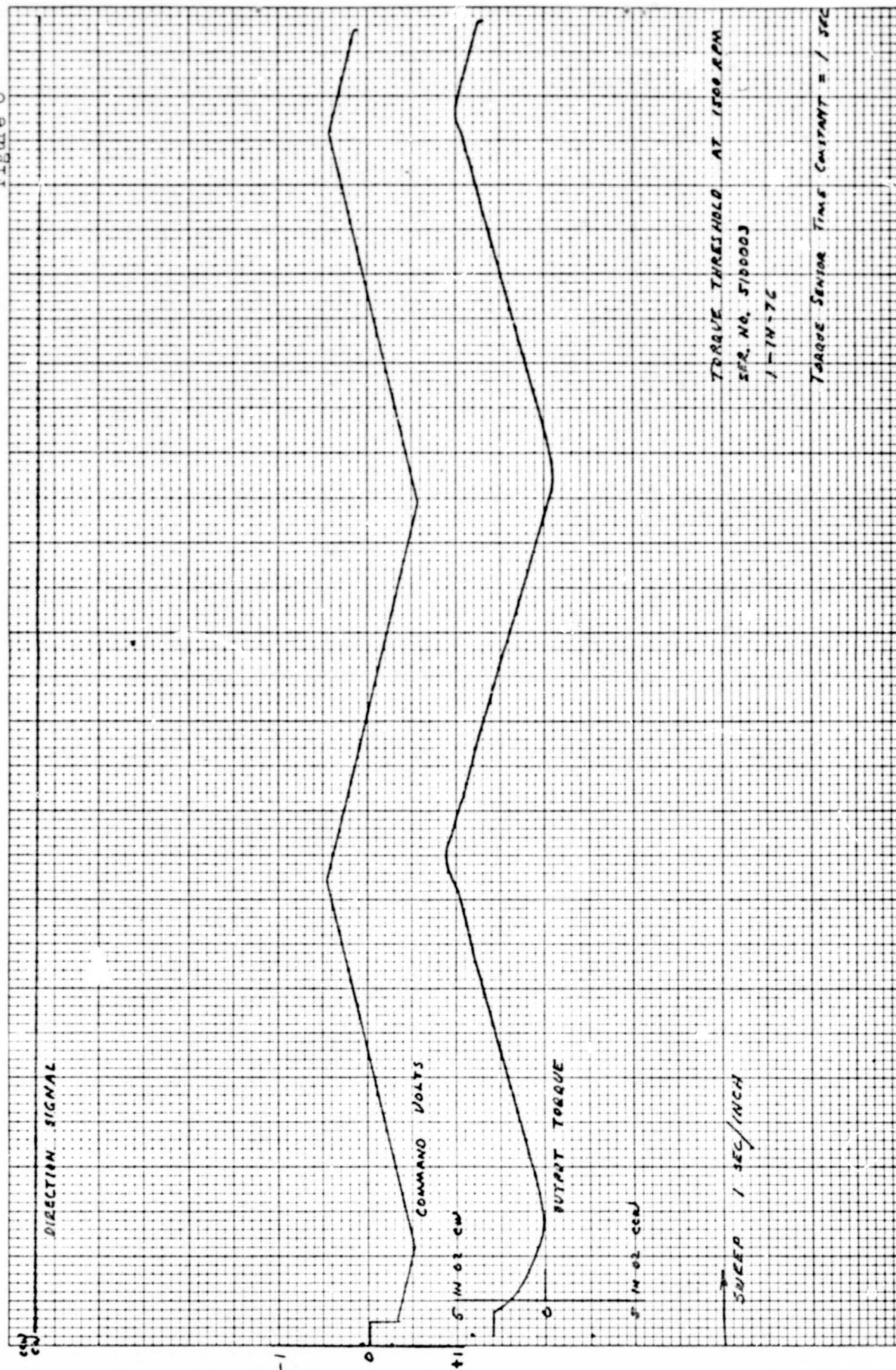


Figure 6



results show somewhat better threshold at stall and there is probably no error at 1500 rpm when the torque fixture lag is taken into account.

IV. RECOMMENDATIONS AND CONCLUSIONS

The three Reaction Wheels provided met all of the performance requirements of the contract. Minor improvements to the test procedure in the areas of torque threshold and response time could be made if better accuracy is required.

Maintenance should be on an "as required" basis and it is recommended that the units be returned to the factory if any malfunctions occur.